Survival and Growth of Young Southern Pine After Simulated Crown Scorch

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Abstract

The effects of defoliation level and timing on growth and survival of young loblolly (Pinus taeda L) and slash (P. elliottii Engelm.) pines were studied in pine plantations in 1986. Five defoliation levels (100, 95, 66, 33, or 0 percent) and four defoliation times (January, April, July or October) were replicated at four Coastal Plain locations (two in Georgia and one each in Florida and South Carolina). Needles were manually removed from the ground up through the crown to simulate scorch effects on foliage. Ninety-three percent of the loblolly pines defoliated 100% in October and 40% of the slash pines defoliated 100% in October were killed. Diameter and height growth of trees defoliated at the three most severe levels were reduced.

Résumé

Une étude était entreprise en 1986 pour déterminer les effets du degré et de la période de défoliation sur le taux de croissance et de survie de jeunes pins taedas (Pinus taeda L.) et pins d'Elliot (Pinus elliottii Engelm.) Quatre endroits de la plaine côtière (2 en Georgie, un en Floride et un autre en Caroline du Sud) ont été soumis à cinq degrés de défoliation (100, 95, 66, 33 ou 0%) à quatre périodes de défoliation différentes (janvier, avril, juillet ou octobre), traitements assortis de répétitions. Les aiguilles ont été enlevées à la main, de la base au sommet de la cime, pour simuler les effets du roussissement sur le feuillage. Un taux de mortalité de 93% a été observé chez les pins taedas ayant été complètement défoliés en octobre et 40% des pins d'Elliot ayant été complètement défoliés en octobre sont morts. Les arbres soumis aux trois plus importants degrés de défoliation présentaient toutefois une diminution significative de l'accroissement de leur diamètre et de leur hauteur.

Introduction

Prescribed fire is used extensively in the southern United States to manage southern pine stands. This practice, as well as wildfire, sometimes can result in damage to crop trees. Roots, stems, and crowns can be individually or collectively affected. Knowledge of the magnitude and duration of a tree's response to various levels of damage is a prerequisite for evaluating management alternatives. Wade and Johansen (1986) reported that the factors affecting postfire survival and growth of southern pine have not yet been adequately described and in fact are often contradictory. Growth reductions and increases as well as differing mortality have been reported for identical levels of scorch (Villarubia and Chambers 1978, Waldrop and Van Lear 1984). A study was established in January 1986 to better delineate the effects of timing and severity of crown defoliation on southern pine survival and growth.

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Methods

To study the survival and growth of young southern pines after simulated crown scorch, this study was established in 4-year-old loblolly (Pinus taeda L.) and slash (P. elliottii Engelm.) pine plantations on the South Carolina, Georgia, and Florida coastal plain in 1986. A factorial experiment with 15 replications was established at each of 4 locations. Loblolly pine sites were established at Bainbridge, Ga. and Branchville, S.C. and slash pine sites at Palatka, Fl. and Waycross, Ga. in January. Study trees were 2.5 to 3.5 meters tall, healthy, and of good form at the time of selection. One of five levels of defoliation (0, 33, 66, 95, and 100 percent) and one of four timings of defoliation (January, April, July, or October) were randomly assigned to each of 20 trees within a replication (fig.1).

Foliage was removed manually during the first two weeks of April, July or October 1986 or January 1987. Foliage removal began at ground level and progressed up through the crown to simulate crown scorch. This technique simulated the effects of foliage drop resulting from prescribed fire, without incorporating any heat effects (i.e. heat damage to buds). Needles, sheaths, and fascicles were stripped off of branches and the bole. Care was taken not to accidently remove any buds during the stripping process.

Initial tree diameter at breast height (d.b.h., 1.37 m above ground) and total height were measured in early 1986 before bud elongation. D.b.h. and total height were remeasured in January of 1987, 1988, and 1989. Survival of each tree was noted by observing bud condition. The number of annual growth flushes was recorded at selected locations and times. Mean initial height and d.b.h. did not differ between defoliation levels or timings. A wildfire burned through a portion of the Branchville site during the winter of 1987. Survival of the trees unaffected by the wildfire was similar to survival at Bainbridge.

Analysis of variance (ANOVA) was used to test for differences in final d.b.h. and height for each level and timing of defoliation. As expected, the interactions between timing and level of defoliation were significantly different from 0. Selected line plots of mean d.b.h. and height were graphed by location by timing of defoliation (figs. 2-5). The terms d.b.h. growth rate and height growth rate refer to the slopes of these line plots.

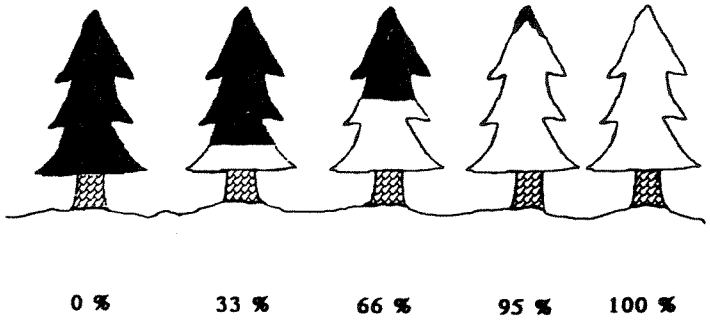

FIG 1. Manual defoliation levels applied to 4-year-old loblolly (Pinus taeda L) and slash (P. elliottii Engel.) pine in the coastal plain of South Carolina, Georgia, and Florida.

Table 1. Effects of defoliation level and timing on diameter and height of 4-year-old loblolly (Pinus taeda L) and slash (P. elliottii Engelm.) pines in the South Atlantic Coastal Plain.

	Growth Variable[1]	
Pine species	Diameter	Height
Loblolly (Bainbridge)	L, T	L, T, L*T
Slash (Palatka)	L, T, L*T	L, L*T
Slash (Waycross)	L, T, L*T	L, T. L*T

[1]Letters indicate significant factors in ANOVA ($P <= 0.025$). L = defoliation level (0, 33, 66, 95, or 100 percent crown defoliation), T = defoliation timing (within first 2 weeks of April, July, or October 1986 or January 1987), L*T = interaction between defoliation level and timing.

Results

Defoliation level significantly altered d.b.h. and height of slash and loblolly pine at all three sites ($P < 0.01$) (table 1). Timing of defoliation significantly altered d.b.h. and height at Waycross and Bainbridge, but not Palatka. The interactions between level and timing were statistically significant ($P < 0.05$) for slash pine d.b.h. and height, and for loblolly pine d.b.h. (table 1). In both species, d.b.h. and total height growth loss increased as defoliation increased. Severe defoliation (95 and 100 percent) contrasted with no defoliation. Results for the moderate defoliations (33 and 66 percent) followed the general trends that severe defoliation did; however, growth reductions were not as numerically large. These are preliminary results and mean separation techniques such as Duncan's Multiple Range have not been used. Thus the growth reductions may or may not all be statistically different.

SLASH PINE

Growth patterns at Waycross and Palatka were similar so only Palatka results are presented graphically. Undefoliated trees had the greatest mean d.b.h. (fig. 2). Complete defoliation reduced d.b.h. by 12 to 33 percent (table 2). The 66 percent defoliations reduced d.b.h. by up to 16 percent.

D.b.h. growth rate, indicated by slope of the line plots, recovered within 12 months for all defoliations except the complete October defoliation (fig. 2). April and July treatments, applied during the growing season,

Table 2. Loss of diameter and height growth due to seasonal defoliation of young slash pine (Pinus elliottii Engelm.) in the Florida and Georgia coastal plain.

Defoliation timing	Site[1]	Defoliation level (pct)[2] 66	95	100
January	P	11(3)	23(15)	23(14)
	W	7(4)	18(13)	26(21)
April	P	7(3)	11(9)	13(9)
	W	6(6)	6(10)	12(13)
July	P	8(1)	15(10)	21(18)
	W	16(10)	14(10)	20(17)
October	P	7(3)	21(13)	33(22)
	W	14(8)	22(18)	27(24)

[1]P = Palatka, Fl.; W = Waycross, Ga.
[2]Percentage of foliage hand removed from ground upward.

depressed d.b.h. growth rate in the same growing season that defoliation occurred. D.b.h. growth rate reduction was not apparent until the growing season following the October and January treatments -- dormant season applications.

Slash pine total height was also reduced by defoliation (fig. 3). Total height of the complete defoliations was reduced 9 to 24 percent (table 2). January and April defoliations reduced height growth rate in the growing seasons of defoliation. July and October growth reductions occurred during the growing season after treatment. This result is not considered surprising as height growth is primary growth and occurs early in the growing season. Sixty-five percent of the height growth of southern pine seedlings in North Carolina was completed by July 1 (Kramer 1943).

Forty percent of the trees completely defoliated in October died by January 1989 at Palatka. Slash pine mortality did not occur at Waycross or in partially defoliated trees at Palatka. No sign of disease or insect attack was observed at Palatka so mortality was attributed to the defoliation treatment.

LOBLOLLY PINE

As with slash pine, defoliation reduced d.b.h. (fig. 4). D.b.h. growth of the trees treated in January and April recovered the next growing season. July d.b.h. growth rate recovered two growing seasons after defoliation. The complete October defoliation growth rate has yet to recover. D.b.h. of the completely defoliated trees was reduced 7 to 57 percent (table 3).

January and April height growth rates were reduced in the growing season of treatment; July and October height growth rates the following growing season (fig. 5). The total height of completely defoliated trees was

Table 3. Loss of diameter and height growth due to seasonal defoliation of young loblolly pine (Pinus taeda L) in the Georgia coastal plain.

Defoliation timing	Defoliation level (pct)[1] 66	95	100
January	0(4)	8(17)	11(14)
April	5(11)	7(13)	10(16)
July	1(7)	5(14)	7(18)
October	2(11)	12(23)	57(48)

[1]Percentage of foliage hand removed from ground upward.

reduced 14 to 48 percent (table 3). Except for the complete October defoliation, height growth rate of all treatments has recovered.

Mortality was observed in only one category: the complete October defoliation. Since no insect damage was noted, mortality was attributed to defoliation. Fourteen of the 15 trees in this category died within 15 months of defoliation. Diameter growth of the surviving tree has been nonexistent since 1987 and the top died back during the 1987 growing season to the initial height of 2.74 meters. A lateral bud has assumed dominance.

Discussion

D.b.h. and height growth of the trees defoliated in April were generally reduced during the 1986 growing season (Weise et al. 1987). Approximately one-half of the year's volume growth was lost. All timings of defoliation have resulted in a growth loss that has not been regained. Recovery patterns of both species after defoliation were similar. D.b.h. and height growth of the January and April trees recovered the following growing season. Complete defoliation reduced d.b.h. from 12 to 57 percent and total height by 9 to 48 percent.

The mortality response to defoliation is of particular interest. Timing of defoliation appears to be critical. In both species, only trees completely defoliated in October died. All trees defoliated at all other timings and levels survived. Foliage removal just before dormancy may interrupt the storage of sugars which would be used during the winter months when the photosynthetic rate is reduced because of low temperatures. The trees may not have had sufficient resources to refoliate the following spring and thus died.

Trees severely scorched during other time periods often do die, but results reported here suggest that mortality associated with crown scorch from January through July results from stem, bud, or root damage--

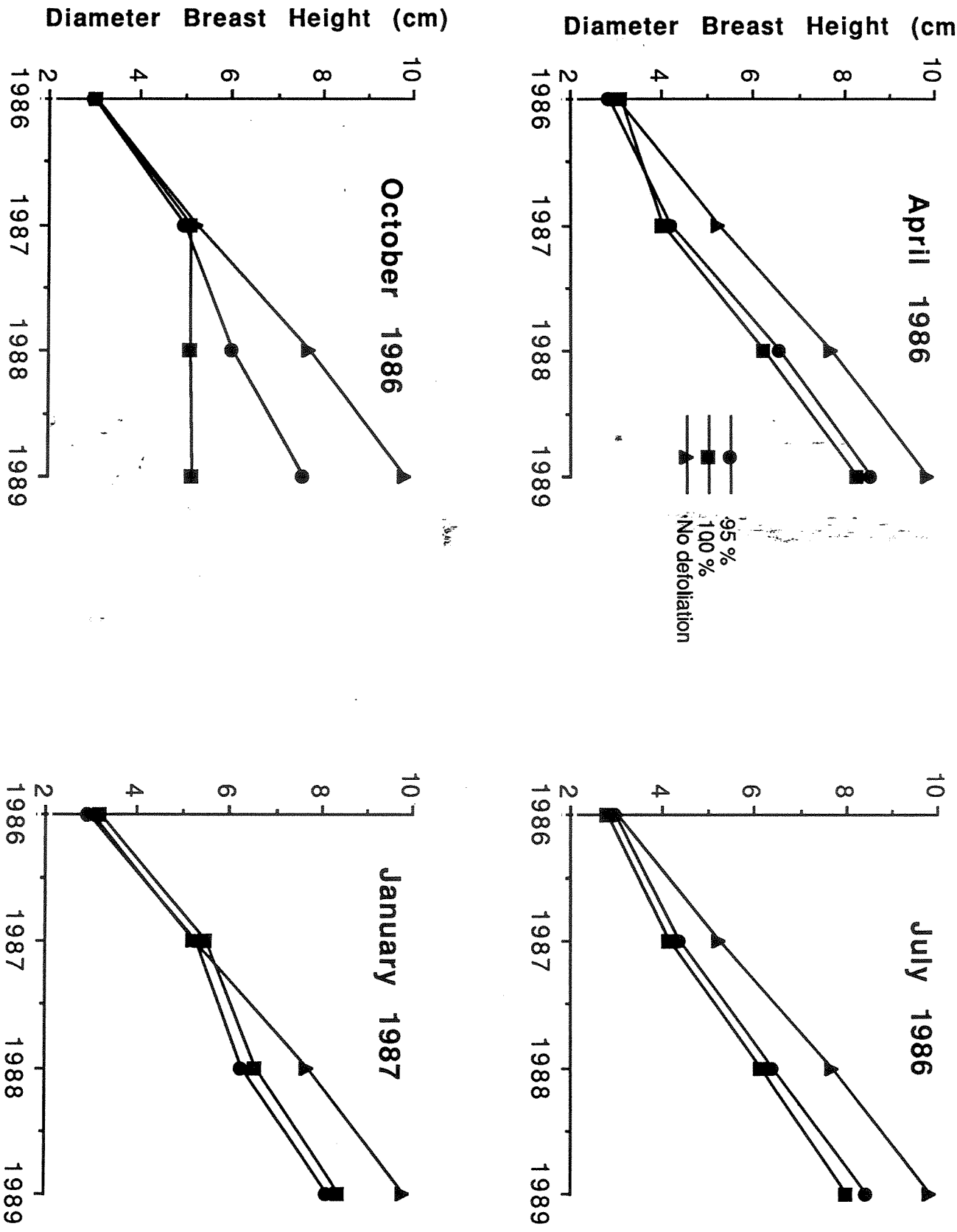

FIG 2. Diameter breast height response of 4-year-old plantation slash pine (Pinus elliottii Engelm.) to severe defoliation on a flatwoods site near Palatka, Florida.

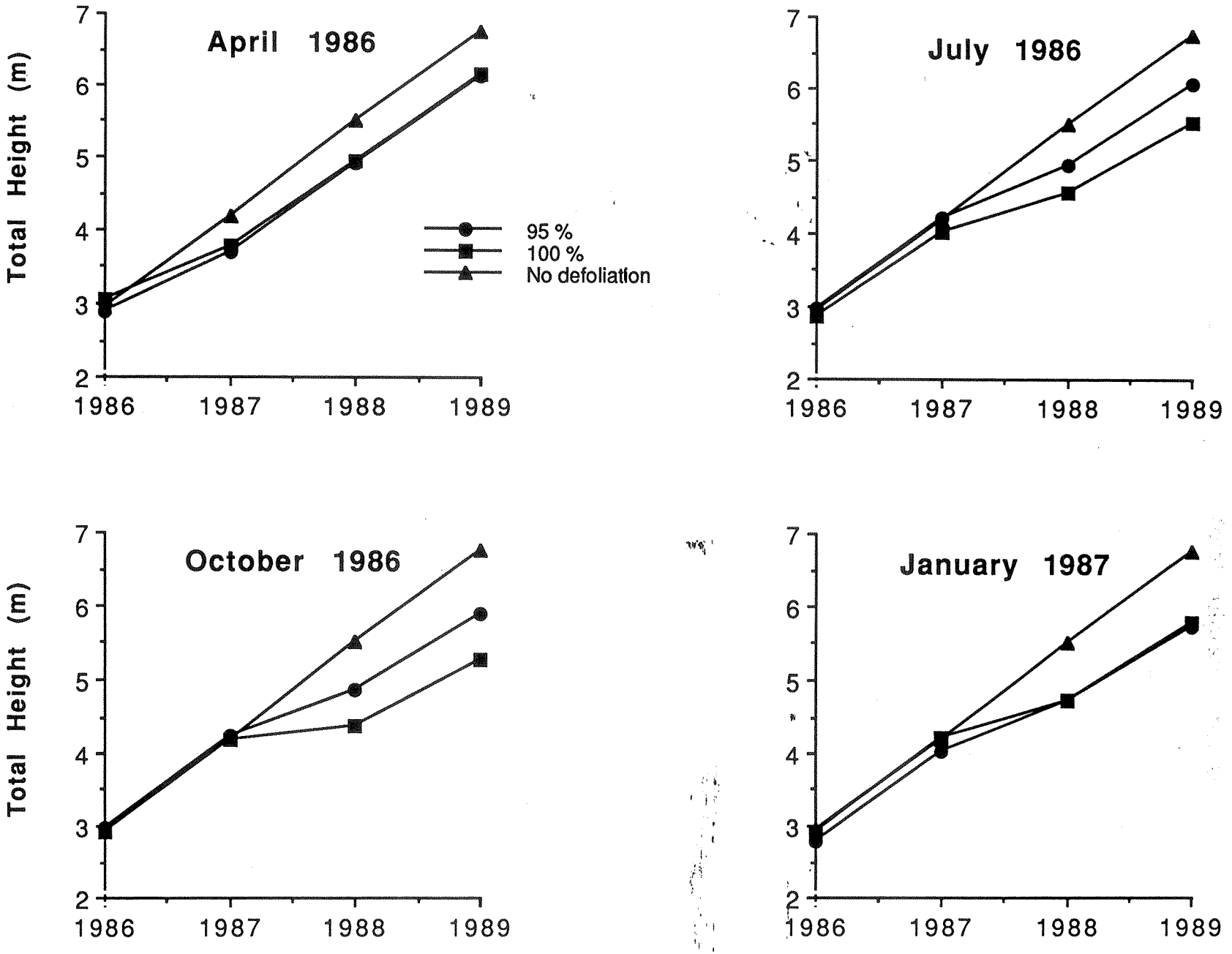

FIG 3. Total height response of 4-year-old plantation slash pine (Pinus eliottii Engelm.) to severe defoliation on a flatwoods site near Palatka, Florida.

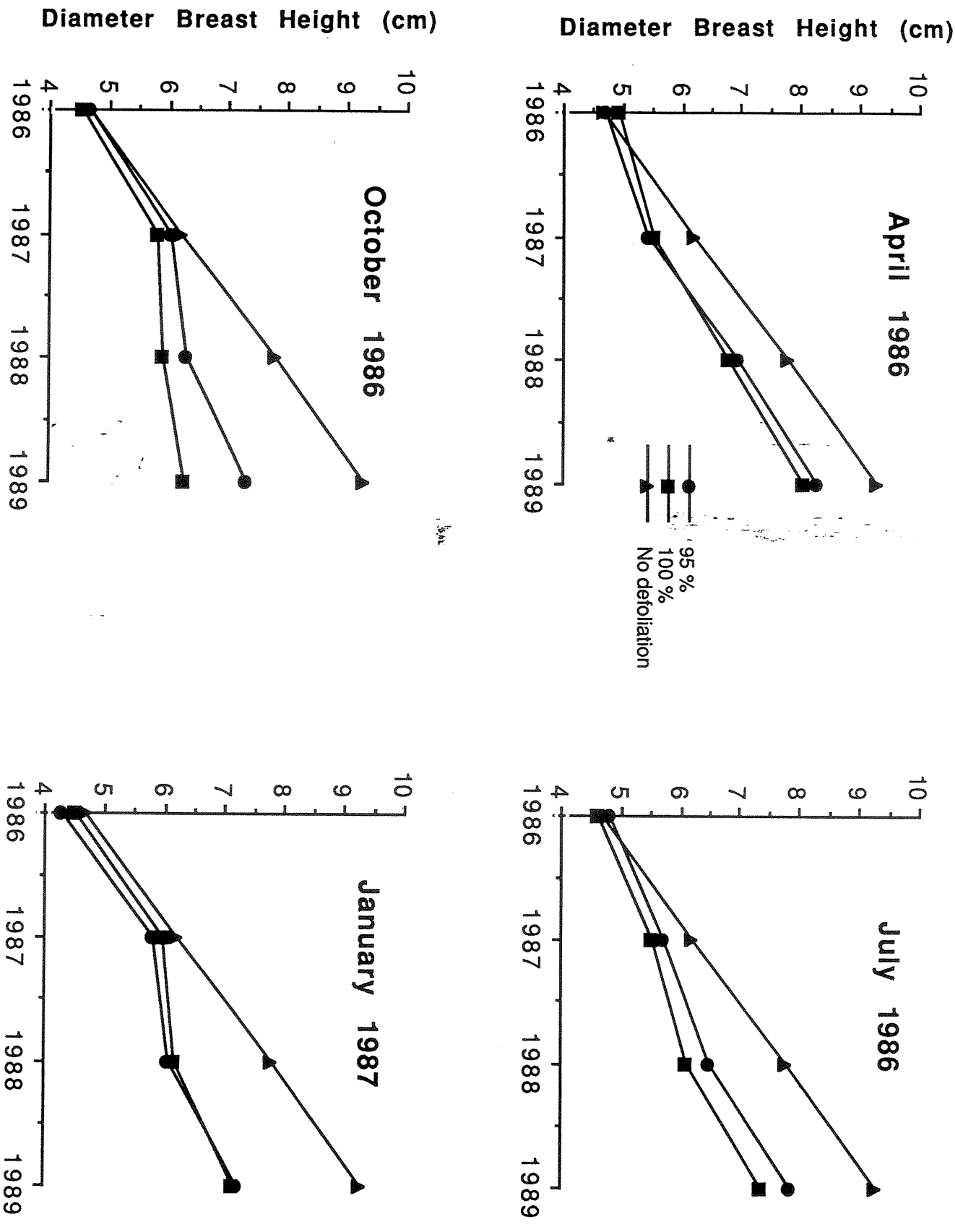

FIG 4. Diameter breast height response of 4-year-old plantation loblolly pine (Pinus taeda L.) to severe defoliation on a coastal plain site near Bainbridge, Georgia.

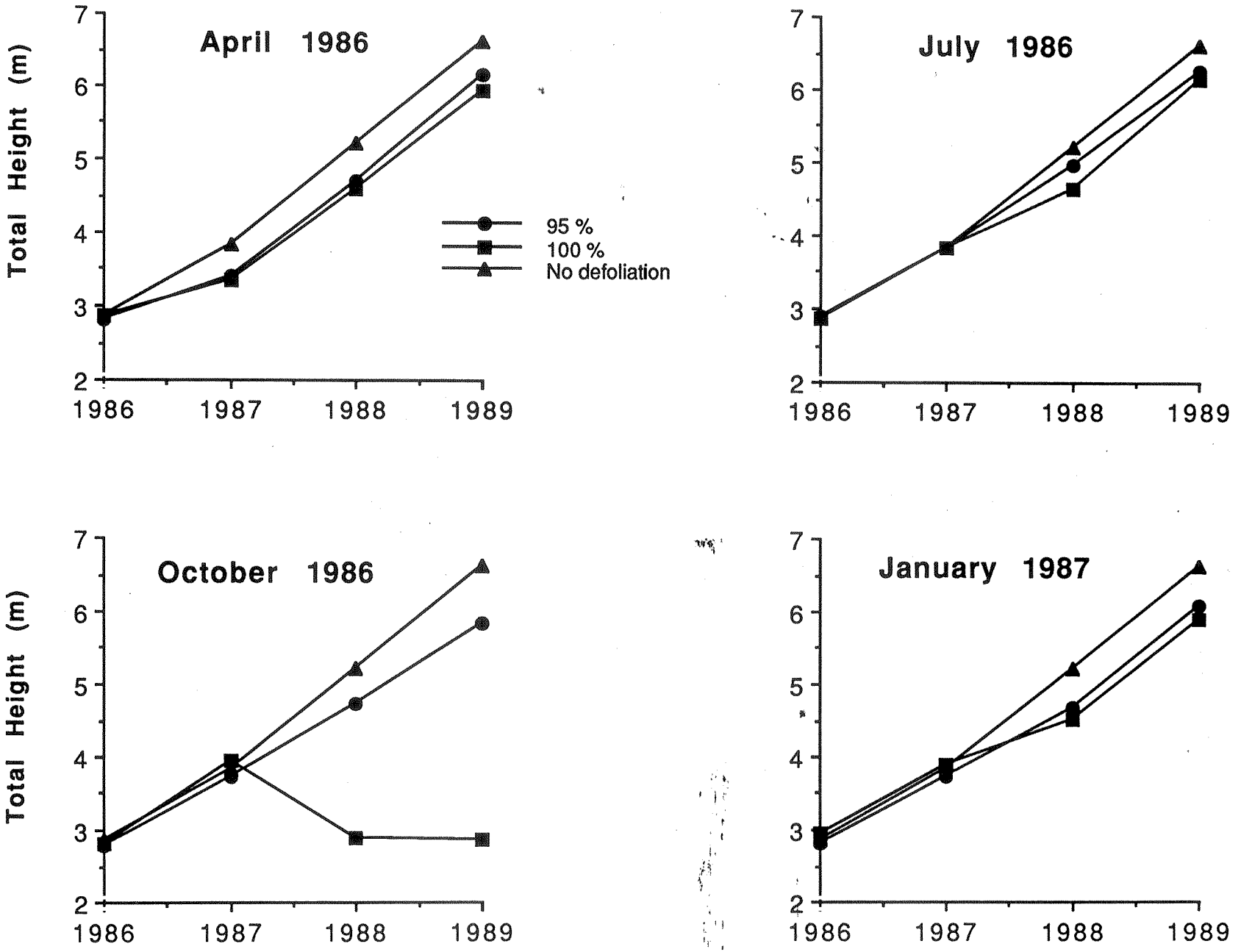

FIG 5. Total height response of 4-year-old plantation loblolly pine (Pinus taeda L) to severe defoliation on a coastal plain site near Bainbridge, Georgia.

not foliage loss. In a study involving more than 1,200 wildfire damaged loblolly pines less than 8 years old, Wade (1985) found only slight mortality occurred from crown scorch alone. However, as soon as some foliage was consumed, mortality increased significantly. Crown consumption implies bud damage which will cause tree mortality if extensive enough.

We did not evaluate the impact of bud damage on survival and growth of southern pines in this study. Intense wildfires can cause extensive stem damage but this is usually associated with crown consumption and thus bud injury. Johansen and Wade (1986) showed stem damage alone can kill small diameter southern pines. Once basal diameters exceed 5 cm, the bark becomes thick enough to protect the stem cambium. Root damage is a possibility, especially in older trees that can not replace heat-killed feeder roots as fast as rapidly growing younger trees. Thus we hypothesize that bud damage is the principal cause of death once trees have attained a diameter of several centimeters.

Waldrop and Van Lear (1984) examined the effects of prescribed fire on unthinned 17-year-old loblolly pine. The prescribed burns were conducted in June, August, or October 1979. Complete crown scorch (foliage and tips of branches scorched) occurred in the high intensity fires. They reported that "diameter growth of trees subjected to even high-intensity flames was not significantly affected in the year following burning." Our results contradict their statement.

All severe (> 66 percent) defoliation level/timing combinations resulted in a d.b.h. and height growth loss for slash and loblolly pine. Complete defoliations of 4-year-old loblolly pines resulted in d.b.h. growth reductions of 16, 18, and 48 percent for April, July, and October defoliations, respectively; slash pine d.b.h. growth reductions were 12, 20, and 30 percent. Growth was reduced within 12 months of defoliation. these growth losses are similar to those reported for older southern pines. Villarubia and Chambers (1978) documented a significant d.b.h. growth loss in completely scorched 20 year old loblolly pine in the growing season following an October 1976 prescribed fire. Johansen and Wade (1987) reported that complete scorch resulted in a 34 to 68 percent loss in d.b.h. growth of 25 year old plantation grown slash pine for the 2 year period after a January 1982 prescribed fire. Thus, although loblolly and slash pine can withstand complete defoliation during the winter, spring, and summer months, one should expect significant short-term growth loss. Johansen (1975) found the growth rate of severely crown damaged slash pine initially decreased and then increased until both slightly and severely damaged trees outgrew the undamaged control trees. This does not appear to be happening in our current study. We simulated the effects of fire, and thus the trees did not get the nutrient mineralization and understory control benefits accruing from an actual fire.

Conclusions

Partial and complete defoliation reduced d.b.h. and height growth of 4-year old loblolly and slash pines. Growth losses occurred within 12 months of defoliation. October defoliations had the greatest impact on growth--93 percent of completely defoliated loblolly pine died within 15 months and 40 percent of the completely defoliated slash pine died within 27 months. Winter, spring, and summer defoliations did not cause mortality.

Prescribed burning during the dormant season should not cause mortality -- provided only foliar scorching results. However, severe crown scorch may cause a d.b.h. and height growth loss of up to 50 percent. Care should be taken in planning and conducting prescribed burns in young southern pine stands in order to minimize the potential loss.

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